the ENERGY lab

PROGRAM FACTS

Hydrogen Turbines

Hydrogen Turbine Program

Overview

The Department of Energy (DOE) is committed to using coal in ways that are cleaner and more efficient, with reduced carbon dioxide (CO_2) emissions. Integrated gasification combined cycle (IGCC) power plants with carbon capture can meet this challenge. An essential part of an IGCC power plant that captures CO_2 is the hydrogen-fueled turbine. The Hydrogen Turbine Program addresses key technologies needed to enable the development of advanced turbines and turbine-based systems that will operate cleanly, efficiently, and at low cost when fueled with coal-derived synthesis gas and hydrogen fuels.

Program

When integrated with a steam turbine, advanced gas turbines form the combined cycle (CC) electric power generation module in the IGCC power plant. Advancing hydrogen turbine performance in the IGCC power plant offers the most significant near-term performance benefit for reducing emissions and cost, while increasing efficiency and capturing CO_2. However, significant scientific and engineering challenges must be overcome to realize these potential benefits. Some of these challenges include managing the fundamentals of high-temperature hydrogen combustion while minimizing nitrogen oxide (NOx) emissions, developing improved material systems to withstand higher temperatures and high heat flux, and developing advanced airfoils with improved aerodynamics and mechanical strength.

The Hydrogen Turbine Program has established a portfolio of research projects to solve these scientific and technological challenges. These projects include contributions from national laboratories, universities, small businesses, and gas turbine manufacturers.

The Hydrogen Turbine Program is organized into three key program elements:

Hydrogen Turbines for IGCC with Carbon Capture: The Hydrogen Turbine Program, in collaboration with the nation's leading large-frame turbine manufacturers, is pursuing development of advanced turbine technology and turbine-based systems. These cost-shared projects build on the developers' knowledge and expertise along with insight from national laboratories and universities. Hydrogen-fueled turbines developed through these projects will be highly efficient, low-cost, and have low-emissions that will make possible an IGCC power plant that captures and stores CO_2.

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The University Turbine Systems Research (UTSR) Program: UTSR solicits universities and colleges with gas turbine expertise throughout the U.S. to participate in the DOE's turbine research and development (R&D). Research priorities are set by the DOE in collaboration with the gas turbine industry to resolve scientific and engineering issues associated with using coal-derived synthesis gas and hydrogen fuels. Results from UTSR projects are provided to industry and made available in the open literature for application to gas turbine development.

Advanced Research: The advanced research area sponsors work with national laboratories, small businesses, and the gas turbine industry to resolve specific scientific and engineering questions that apply to new concepts for gas turbines. This work focuses on fundamentals of large-frame gas turbines for IGCC applications as well as new and innovative turbine-based technologies.

The program is augmented by a portfolio of Small Business Innovative Research (SBIR) projects; American Recovery and Reinvestment Act (ARRA) funding for advancing industrial application of carbon capture, utilization, and storage (CCUS); and the NETL Regional University Alliance (RUA), an applied research collaboration that utilizes the extensive expertise and facilities available at NETL and five nationally recognized regional universities.

Goals and Objectives

The DOE Office of Fossil Energy's Office of Clean Coal has developed a strategic plan that is focused on:

- Research, development and demonstration to enable CCUS deployment in the post-2020 timeframe.
- Sufficient demonstrations of first-generation CCUS and power plant technologies to provide confidence that they can be safely and reliably integrated into power plant operations.
- Development and demonstration of new, advanced second-generation CCUS and power plant technologies for deployment in the post-2020 timeframe.

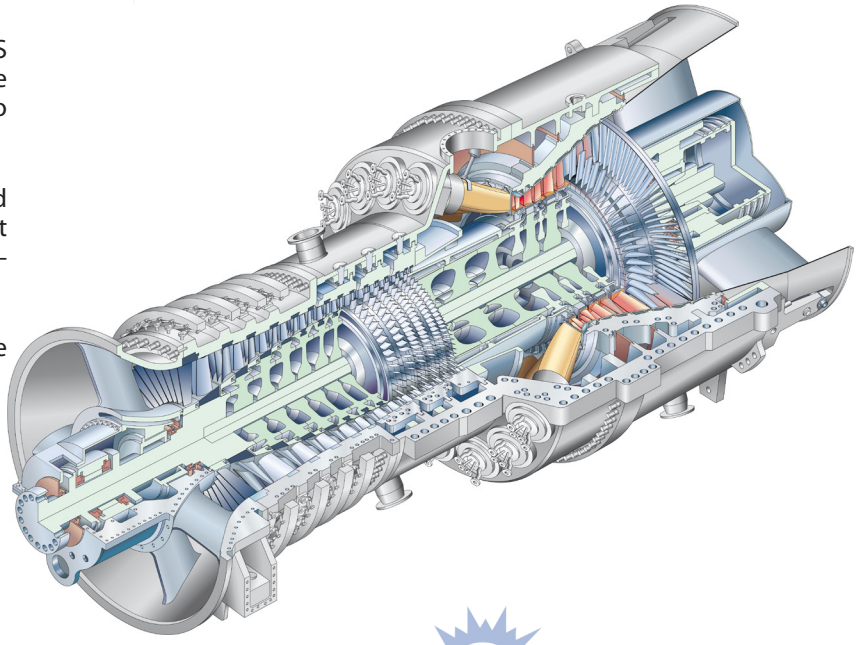
The following best practice performance targets have been established in response to this plan:

- < 10% increase in cost of electricity (COE) with CCUS at 90% capture (pre-combustion)
- < 35% increase in COE with CCUS at 90% capture (post- and oxy-combustion)
- > 90% CO_2 capture
- > 99% CO_2 storage permanence
- +/- 30% storage capacity accuracy

In response to these targets, the Hydrogen Turbine Program has laid out goals to deliver hydrogen-fueled CC power modules for the 2020 time horizon that demonstrate the following achievements:

- Efficiency
  - 2–3 % points improvement in CC efficiency (2010) and 3–5 % points by 2015 above the baseline
  - + 4 % points improvement in overall IGCC plant efficiency with CCUS
- Cost Reduction
  - 20–30 % reduction in CC capital cost
  - + 25 % reduction (>$943/kW) in total overnight capital cost for IGCC w/CCUS
  - + 25 % reduction (>$88/MWh) in cost of electricity for IGCC w/ CCUS
- Emissions
  - Turbine NOx emissions in single digits (@15 % O_2)
  - IGCC plant optimized for firing temperature with 2 ppm NOx at the stack (includes selective catalytic reduction)

The Hydrogen Turbine Program will strive to meet these goals through R&D on hydrogen combustion, aerodynamics, heat transfer and cooling, leakage control, and material systems. Success in these areas will contribute significantly to the performance of IGCC power plants with carbon dioxide capture. With similar success from other Office of Fossil Energy R&D programs, it is likely that all of the performance penalties due to carbon capture in an IGCC power plant can be recovered.



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